B3 conc'd

each $i = 1, 2, 3$; if $X(u,v)$ is an output signal of a color i pixel sensor, then $\hat{X}_i(u,v) = X(u,v)$, and if $X(u,v)$ is an output signal of an IR pixel sensor or a color j pixel sensor where $j = 1$ denotes magenta, $j = 2$ denotes yellow, and $j = 3$ denotes cyan such that $j \neq i$, then $\hat{X}_i(u,v)$ is an average of the output signals of nearest neighbor color i pixel sensors.

Remarks

Claims 1, 3-9, and 11-16 were rejected under 35 U.S.C. §112, second paragraph; claim 1 was rejected under 35 U.S.C. §102(e) as being anticipated by Inoue et al., U.S. patent 5,926,238 ("Inoue"); claims 2, 3, and 9-11 were rejected under 35 U.S.C. §103(a) as being unpatentable over Inoue; and claims 4-8 and 12-16 were rejected under 35 U.S.C. §103(a) as being unpatentable over Inoue in view of Lu et al, U.S. patent 5,805,217 ("Lu").

Several issues were raised in the office action of 25 January, 2001 ("Office Action"), page 2, item 3 regarding the 35 U.S.C. §112, second paragraph rejection of the claims. It was indicated in the Office Action that it was unclear in claims 1 and 9 whether "green, red and blue also refers to pass filters or if pass filter only refers to infrared." It should be clear from the grammatical usage in the claim, as well as specific references in the specification, that the term pass filters also refers to green, red, and blue. For example, in the specification, page 4, line 19, specific reference is made to red, green, and blue pass filters.

It was also indicated in the Office Action that in claims 3, 4, 8, 11, 12, and 16 it was unclear as to what n and m represent, in claims 1 and 11 it was unclear as to the representation of i and j in $f_{i,j}$, and for claims 5-7 and 13-15 the variable j was not defined. All of these claims have been amended to clear up these issues. Specifically, claims 3, 4, 8, 11, 12, 16 are amended to indicate that subscripts on f denote row-column position, and that n and m are indices. Also, claims 5-8 and 13-16 are amended to define the index j.

Accordingly, it is believed that the claims satisfy 35 U.S.C. §112, second paragraph.

In the Office Action, item 5, page 3, it was indicated that claim 1 was anticipated by Inoue because in Fig. 8B of Inoue, there is disclosed a color filter array comprising a unit array having green, red, blue, and infrared pass filters in relative proportions 4:1:1:2, respectively. However, Applicants respectfully disagree with this assertion. The unit array in Fig. 8B has green, red, blue, and infrared pass filters in relative proportions of 1:1:1:1. This can easily be observed by repeating the pattern of filters indicated in Fig. 8B. Also, this can easily be observed from Inoue, column 6, last paragraph, where it is indicated that "R (red), G (green) and B (blue) are formed in chequer-board pattern … . In addition, one in every four pixels is composed of an IR (infrared or near-infrared transmitting) filter 303." Referring to Fig. 8B, it is seen that R, G, and B are repeated in chequer-board pattern, where in every other row, every other element is replaced with an IR filter. The net result is that all filters are in equal numerical proportion.

For the above reason, claim 1 is not anticipated by Inoue.

In item 7, page 3 of the Office Action, it was stated that claims 2, 3, and 9-11 were obvious in light of Inoue. However, the argument that follows in the Office Action is based upon the assertion that Inoue discloses a unit array having green, red, blue, and infrared pass filters in relative proportions 4:1:1:2, respectively. But as stated earlier, this assertion is incorrect. Nowhere does Inoue suggest or motivate a color filter array as claimed in claims 2, 3, and 9-11.

It was also indicated in the Office Action, page 4, second paragraph, that a rearrangement of the filter array of Inoue leads to the filter array of the present invention. However, Applicants respectfully assert that the filter array of the present invention is not obtained from Inoue by a rearrangement. Because the unit array of the present invention has a much different numerical proportion of the four pass filters than that of Inoue, a rearrangement of the filters taught by Inoue does not lead to the present invention.

Furthermore, it should be appreciated that there is a very large number of unit arrays that are possible. The number of possible four-by-four unit arrays comprising at most four different types of pass filters, e.g., red, blue, green, and IR, is 4 raised to the power of 16. This number is more than 4 billion! Clearly, it is not obvious from Inoue how to construct the unit array claimed in the present application, and a mere rearrangement of the array taught in Inoue will not lead to the present invention.

Accordingly, it is believed that claims 2, 3, and 9-11 are patentable over Inoue.

In item 8, page 4 of the Office Action, claims 4-8 and 12-16 were rejected as being unpatentable over Inoue in view of Lu. However, the combination of Inoue and Lu does not teach, suggest, or motivate the claimed subject matter. As stated above, Inoue fails to suggest or motivate the unit array of filters as claimed. The recited claim limitations regarding interpolation is in combination with the claimed unit array. The novel aspect of the claimed subject matter is in the combination of the unit array and interpolation procedure, which is neither taught, suggested, or motivated by the cited references.

Consequently, it is believed that claims 4-8 and 12-16 are patentable over the cited references.

Accordingly, it is believed that the claims of the present application as now amended are in condition for allowance.

Respectfully submitted,

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Version of Amended Claims with Changes

1. (Twice Amended) A color filter array comprising a unit array, the unit array having green, red, blue, and infrared pass filters in relative numerical proportions 4:1:1:2, respectively.

3. (Amended) A color filter array comprising an array of pass filters $f_{i,j}$, where subscripts on f denote row-column position, wherein for some indices n and m:

$f_{n+1,m+1}$ and $f_{n+3,m+3}$ are blue pass filters;

$f_{n+1,m+2}$, $f_{n+1,m+4}$, $f_{n+2,m+1}$, $f_{n+2,m+3}$, $f_{n+3,m+2}$, $f_{n+3,m+4}$, $f_{n+4,m+1}$, and $f_{n+4,m+3}$ are green pass filters;

$f_{n+1,m+3}$ and $f_{n+3,m+1}$ are red pass filters; and

$f_{n+2,m+2}$, $f_{n+2,m+4}$, $f_{n+4,m+2}$, and $f_{n+4,m+4}$ are infrared pass filters.

4. (Amended) An imaging system comprising:

a color filter array comprising an array of pass filters f, where subscripts on f denote row-column position, wherein for some indices n and m:

$f_{n+1,m+1}$ and $f_{n+3,m+3}$ are blue pass filters;

$f_{n+1,m+2}$, $f_{n+1,m+4}$, $f_{n+2,m+1}$, $f_{n+2,m+3}$, $f_{n+3,m+2}$, $f_{n+3,m+4}$, $f_{n+4,m+1}$, and $f_{n+4,m+3}$ are green pass filters;

$f_{n+1,m+3}$ and $f_{n+3,m+1}$ are red pass filters;

$f_{n+2,m+2}$, $f_{n+2,m+4}$, $f_{n+4,m+2}$, and $f_{n+4,m+4}$ are infrared pass filters; and

an array of pixel sensors responsive to electromagnetic radiation propagating through the color filter array, wherein for some range of position indices u and v, a pixel sensor at position (u,v) provides an output signal $X(u,v)$ indicative of electromagnetic radiation propagating through the color filter array and impinging upon the pixel sensor at position (u,v).

5. (Amended) The imaging system as set forth in claim 4, further comprising

at least one processor to provide interpolated color component signals $\hat{X}_i(u,v)$, i = 1, 2, 3, where i = 1 denotes red, i = 2 denotes green, and i = 3 denotes blue, wherein for each i = 1, 2, 3; if $X(u,v)$ is an output signal of a color i pixel sensor, then $\hat{X}_i(u,v) = X(u,v)$, and if $X(u,v)$ is an output signal of an IR pixel sensor or a color j pixel sensor where j = 1 denotes red, j = 2 denotes green, and j = 3 denotes blue such that $j \neq i$ [pixel sensor], then $\hat{X}_i(u,v)$ is an average of the output signals of nearest neighbor color i pixel sensors.

6. (Amended) The imaging system as set forth in claim 4, further comprising

a memory storage device, wherein stored in the memory storage device are instructions to process interpolated color component signals $\hat{X}_i(u,v)$, i = 1, 2, 3, where i = 1 denotes red, i = 2 denotes green, and i = 3 denotes blue, wherein for each i = 1, 2, 3; if $X(u,v)$ is an output signal of a color i pixel sensor, then $\hat{X}_i(u,v) = X(u,v)$, and if $X(u,v)$ is an output signal of an IR pixel sensor or a color j pixel sensor where j = 1 denotes red, j = 2 denotes green, and j = 3 denotes blue such that $j \neq i$ [pixel sensor], then $\hat{X}_i(u,v)$ is an average of the output signals of nearest neighbor color i pixel sensors.

7. (Amended) A method to interpolate color component signals, comprising:

providing a color filter array comprising

a first row of pass filters, comprising, in order, blue, green, red, and green pass filters;

a second row of pass filters, comprising, in order, green, infrared, green, and infrared pass filters, wherein the second row of pass filters is adjacent to the first row of pass filters so that the blue pass filter of the first row is adjacent to the first green pass filter of the second row;

a third row of pass filters, comprising, in order, red, green, blue, and green pass filters, wherein the first green pass filter of the second row is adjacent to the red pass filter of the third row; and

a fourth row of pass filters, comprising, in order, green, infrared, green, and infrared pass filters, wherein the red pass filter of the third row is adjacent to the first green pass filter of the fourth row;

providing an array of pixel sensors responsive to electromagnetic radiation propagating through the color filter array, wherein for some range of position indices u and v, a pixel sensor at position (u,v) provides an output signal $X(u,v)$ indicative of electromagnetic radiation propagating through the color filter array and impinging upon the pixel sensor at position (u,v); and

interpolating to provide interpolated color component signals $\hat{X}_i(u,v)$, $i = 1, 2, 3$, where $i = 1$ denotes red, $i = 2$ denotes green, and $i = 3$ denotes blue, wherein for each $i = 1, 2, 3$; if $X(u,v)$ is an output signal of a color i pixel sensor, then $\hat{X}_i(u,v) = X(u,v)$, and if $X(u,v)$ is an output signal of an IR pixel sensor or a color j pixel sensor where $j = 1$ denotes red, $j = 2$ denotes green, and $j = 3$ denotes blue such that $j \neq i$ [pixel sensor], then $\hat{X}_i(u,v)$ is an average of the output signals of nearest neighbor color i pixel sensors.

8. (Amended) A method to interpolate color component signals, comprising:

providing a color filter array comprising

a color filter array comprising an array of pass filters f, where subscripts on f denote row-column position, wherein for some indices n and m:

$f_{n+1,m+1}$ and $f_{n+3,m+3}$ are blue pass filters;

$f_{n+1,m+2}$, $f_{n+1,m+4}$, $f_{n+2,m+1}$, $f_{n+2,m+3}$, $f_{n+3,m+2}$, $f_{n+3,m+4}$, $f_{n+4,m+1}$, and $f_{n+4,m+3}$ are green pass filters;

$f_{n+1,m+3}$ and $f_{n+3,m+1}$ are red pass filters; and

$f_{n+2,m+2}$, $f_{n+2,m+4}$, $f_{n+4,m+2}$, and $f_{n+4,m+4}$ are infrared pass filters;

providing an array of pixel sensors responsive to electromagnetic radiation propagating through the color filter array, wherein for some range of position indices u and v, a pixel sensor at position (u,v) provides an output signal $X(u,v)$ indicative of electromagnetic radiation propagating through the color filter array and impinging upon the pixel sensor at position (u,v); and

interpolating to provide interpolated color component signals $\hat{X}_i(u,v)$, $i = 1, 2, 3$, where $i = 1$ denotes red, $i = 2$ denotes green, and $i = 3$ denotes blue, wherein for each $i = 1, 2, 3$; if $X(u,v)$ is an output signal of a color i pixel sensor, then $\hat{X}_i(u,v) = X(u,v)$, and if $X(u,v)$ is an output signal of an IR pixel sensor or a color j pixel sensor where $j = 1$ denotes red, $j = 2$ denotes green, and $j = 3$ denotes blue such that $j \neq i$ [pixel sensor], then $\hat{X}_i(u,v)$ is an average of the output signals of nearest neighbor color i pixel sensors.

9. (Twice Amended) A color filter array comprising a unit array, the unit array having yellow, magenta, cyan, and infrared pass filters in relative numerical proportions 4:1:1:2, respectively.

11. (Amended) A color filter array comprising an array of pass filters $f_{i,j}$, where subscripts on f denote row-column position, wherein for some indices n and m:

$f_{n+1,m+1}$ and $f_{n+3,m+3}$ are cyan pass filters;

$f_{n+1,m+2}$, $f_{n+1,m+4}$, $f_{n+2,m+1}$, $f_{n+2,m+3}$, $f_{n+3,m+2}$, $f_{n+3,m+4}$, $f_{n+4,m+1}$, and $f_{n+4,m+3}$ are yellow pass filters;

$f_{n+1,m+3}$ and $f_{n+3,m+1}$ are magenta pass filters; and

$f_{n+2,m+2}$, $f_{n+2,m+4}$, $f_{n+4,m+2}$, and $f_{n+4,m+4}$ are infrared pass filters.

12. (Amended) An imaging system comprising:

a color filter array comprising an array of pass filters f, where subscripts on f denote row-column position, wherein for some indices n and m:

$f_{n+1,m+1}$ and $f_{n+3,m+3}$ are cyan pass filters;

$f_{n+1,m+2}$, $f_{n+1,m+4}$, $f_{n+2,m+1}$, $f_{n+2,m+3}$, $f_{n+3,m+2}$, $f_{n+3,m+4}$, $f_{n+4,m+1}$, and $f_{n+4,m+3}$ are yellow pass filters;

$f_{n+1,m+3}$ and $f_{n+3,m+1}$ are magenta pass filters;

$f_{n+2,m+2}$, $f_{n+2,m+4}$, $f_{n+4,m+2}$, and $f_{n+4,m+4}$ are infrared pass filters; and

an array of pixel sensors responsive to electromagnetic radiation propagating through the color filter array, wherein for some range of position indices u and v, a pixel sensor at position (u,v) provides an output signal $X(u,v)$ indicative of electromagnetic radiation propagating through the color filter array and impinging upon the pixel sensor at position (u,v).

13. (Amended) The imaging system as set forth in claim 12, further comprising

at least one processor to provide interpolated color component signals $\hat{X}_i(u,v)$, i = 1, 2, 3, where i = 1 denotes magenta, i = 2 denotes yellow, and i = 3 denotes cyan, wherein for each i = 1, 2, 3; if $X(u,v)$ is an output signal of a color i pixel sensor, then $\hat{X}_i(u,v) = X(u,v)$, and if $X(u,v)$ is an output signal of an IR pixel sensor or a color <u>j pixel sensor where j = 1 denotes magenta, j = 2 denotes yellow, and j = 3 denotes cyan such that</u> $j \neq i$ [pixel sensor], then $\hat{X}_i(u,v)$ is an average of the output signals of nearest neighbor color i pixel sensors.

14. (Amended) The imaging system as set forth in claim 12, further comprising

a memory storage device, wherein stored in the memory storage device are instructions to process interpolated color component signals $\hat{X}_i(u,v)$, i = 1, 2, 3, where i = 1 denotes magenta, i = 2 denotes yellow, and i = 3 denotes cyan, wherein for each i = 1, 2, 3; if $X(u,v)$ is an output signal of a color i pixel sensor, then $\hat{X}_i(u,v) = X(u,v)$, and if $X(u,v)$ is an output signal of an IR pixel sensor or a color <u>j pixel sensor where j = 1 denotes magenta, j = 2 denotes yellow, and j = 3 denotes cyan such that</u> $j \neq i$ [pixel sensor], then $\hat{X}_i(u,v)$ is an average of the output signals of nearest neighbor color i pixel sensors.

15. (Amended) A method to interpolate color component signals, comprising:

providing a color filter array comprising

a first row of pass filters, comprising, in order, cyan, yellow, magenta, and yellow pass filters;

a second row of pass filters, comprising, in order, yellow, infrared, yellow, and infrared pass filters, wherein the second row of pass filters is adjacent to the first row of pass filters so that the cyan pass filter of the first row is adjacent to the first yellow pass filter of the second row;

a third row of pass filters, comprising, in order, magenta, yellow, cyan, and yellow pass filters, wherein the first yellow pass filter of the second row is adjacent to the magenta pass filter of the third row; and

a fourth row of pass filters, comprising, in order, yellow, infrared, yellow, and infrared pass filters, wherein the magenta pass filter of the third row is adjacent to the first yellow pass filter of the fourth row;

providing an array of pixel sensors responsive to electromagnetic radiation propagating through the color filter array, wherein for some range of position indices u and v, a pixel sensor at position (u,v) provides an output signal $X(u,v)$ indicative of electromagnetic radiation propagating through the color filter array and impinging upon the pixel sensor at position (u,v); and

interpolating to provide interpolated color component signals $\hat{X}_i(u,v)$, $i = 1, 2, 3$, where $i = 1$ denotes magenta, $i = 2$ denotes yellow, and $i = 3$ denotes cyan, wherein for each $i = 1, 2, 3$; if $X(u,v)$ is an output signal of a color i pixel sensor, then $\hat{X}_i(u,v) = X(u,v)$, and if $X(u,v)$ is an output signal of an IR pixel sensor or a color <u>j pixel sensor where $j = 1$ denotes magenta, $j = 2$ denotes yellow, and $j = 3$ denotes cyan such that</u> $j \neq i$ [pixel sensor], then $\hat{X}_i(u,v)$ is an average of the output signals of nearest neighbor color i pixel sensors.

16. (Amended) A method to interpolate color component signals, comprising:

providing a color filter array comprising

a color filter array comprising an array of pass filters f <u>, where subscripts on f denote row-column position,</u> wherein for some <u>indices</u> n and m:

$f_{n+1,m+1}$ and $f_{n+3,m+3}$ are cyan pass filters;

$f_{n+1,m+2}$, $f_{n+1,m+4}$, $f_{n+2,m+1}$, $f_{n+2,m+3}$, $f_{n+3,m+2}$, $f_{n+3,m+4}$, $f_{n+4,m+1}$, and $f_{n+4,m+3}$ are yellow pass filters;

$f_{n+1,m+3}$ and $f_{n+3,m+1}$ are magenta pass filters; and

$f_{n+2,m+2}$, $f_{n+2,m+4}$, $f_{n+4,m+2}$, and $f_{n+4,m+4}$ are infrared pass filters;

providing an array of pixel sensors responsive to electromagnetic radiation propagating through the color filter array, wherein for some range of position indices *u* and *v*, a pixel sensor at position (u,v) provides an output signal $X(u,v)$ indicative of electromagnetic radiation propagating through the color filter array and impinging upon the pixel sensor at position (u,v); and

interpolating to provide interpolated color component signals $\hat{X}_i(u,v)$, $i = 1, 2, 3$, where $i = 1$ denotes magenta, $i = 2$ denotes yellow, and $i = 3$ denotes cyan, wherein for each $i = 1, 2, 3$; if $X(u,v)$ is an output signal of a color *i* pixel sensor, then $\hat{X}_i(u,v) = X(u,v)$, and if $X(u,v)$ is an output signal of an IR pixel sensor or a color *j* pixel sensor where $j = 1$ denotes magenta, $j = 2$ denotes yellow, and $j = 3$ denotes cyan such that $j \neq i$ [pixel sensor], then $\hat{X}_i(u,v)$ is an average of the output signals of nearest neighbor color *i* pixel sensors.